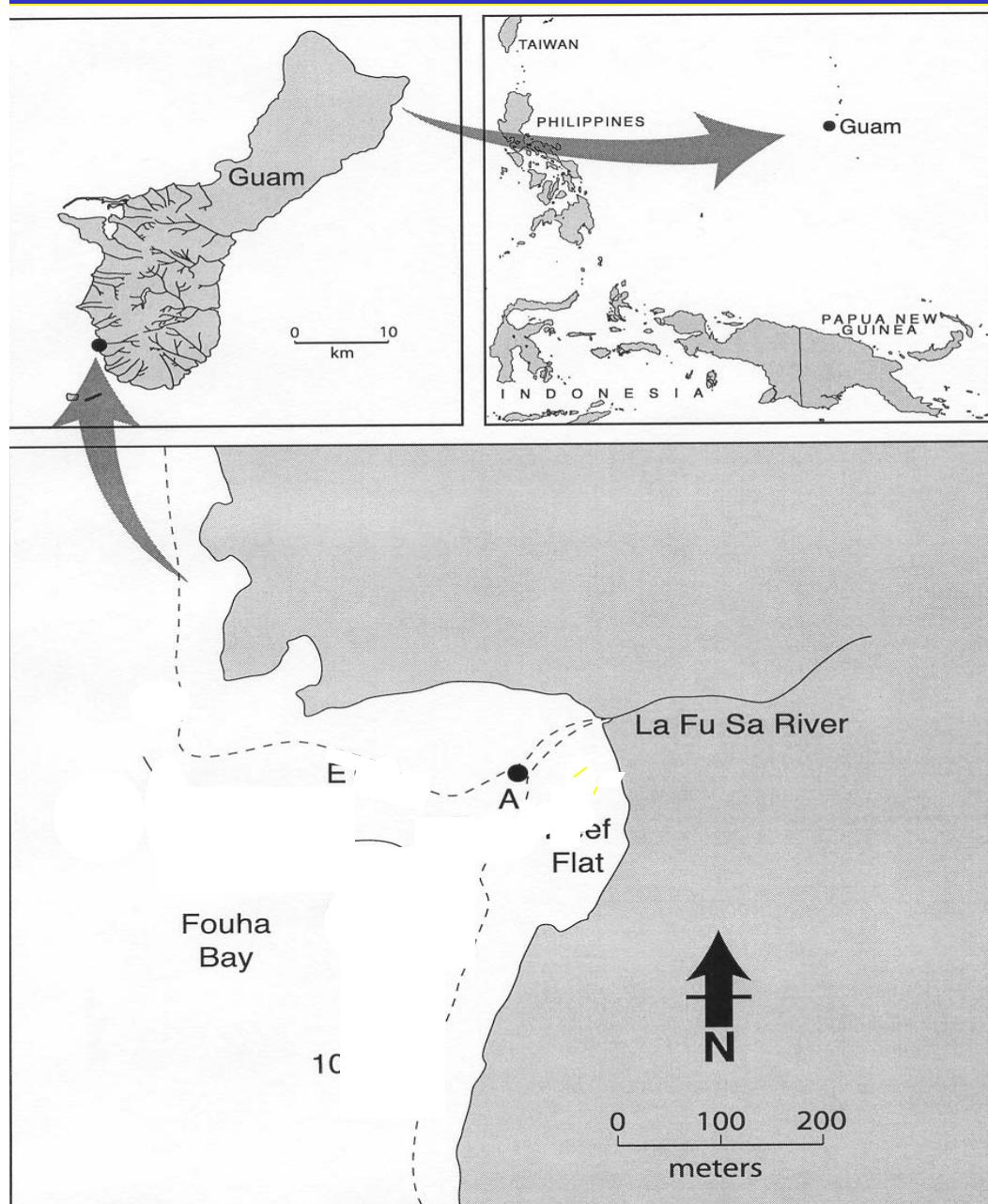


Integrating Coral Reef Ecosystem Integrity and Restoration Options with Watershed-based activities and MPA's in the Tropical Pacific Islands

Dr. Robert H. Richmond, Dr. Michael Hamnett, Dr. Mark Tupper,
Dr. Eric Wolanski, Yimnang Golbuu, Steven Victor, Teina Rongo,
Veikila Vuki, Lena Quinata

Institutions: Kewalo Marine Lab, Univ. of Hawaii; Marine Laboratory,
Univ. of Guam; Social Sciences Research Inst., Univ. of Hawaii,
Australian Inst. of Marine Sciences, Palau Internat'l Coral Reef Center

Fouha Bay



Study Site 1 – Fouha Bay, Guam





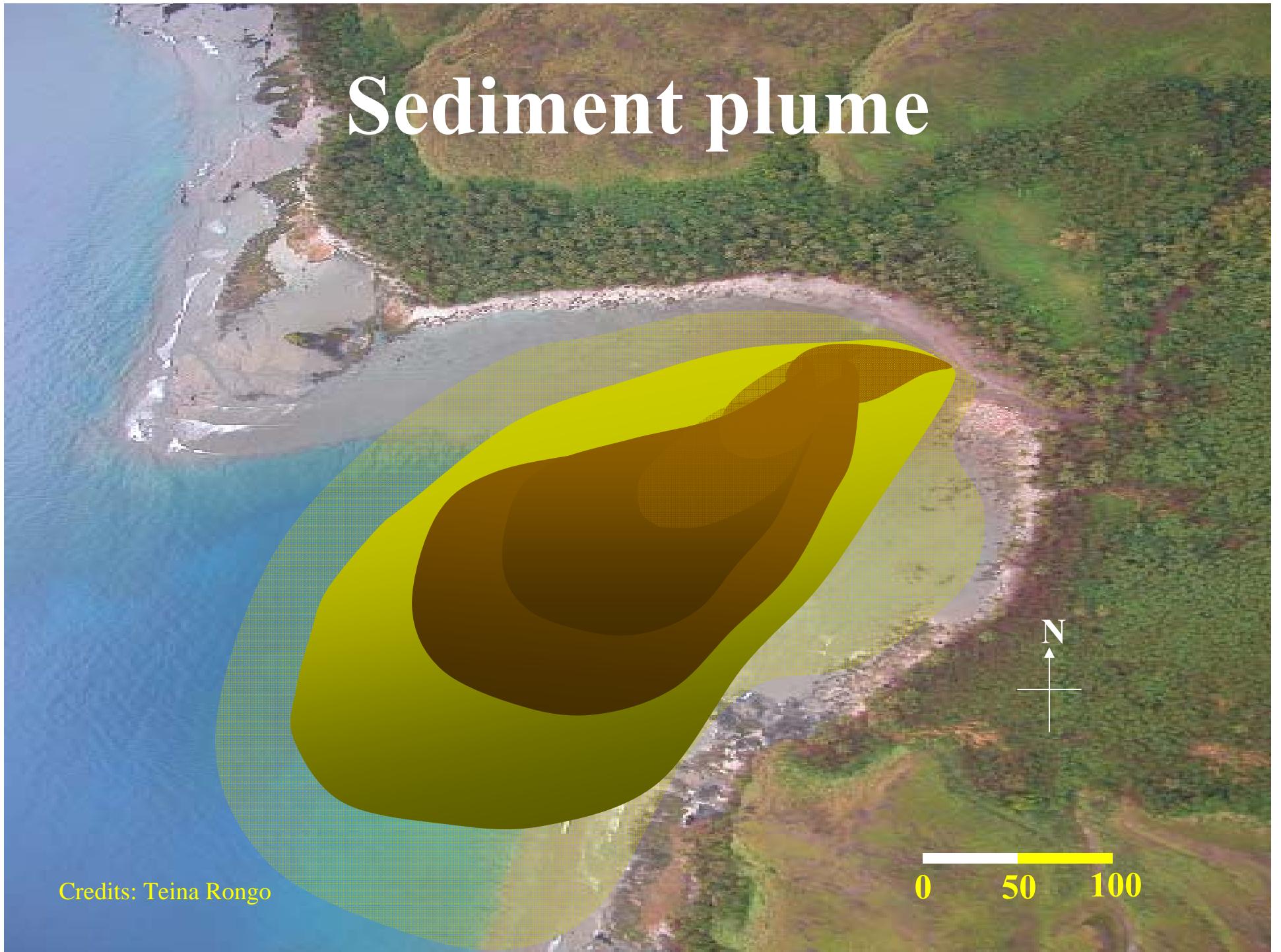
La Sa Fua Watershed

- Watershed size is 5 km^2
- Steep and highly erodible lateritic soil
- Sediment discharge
 - (Scheman, 2002; Wolanski et al., 2003)
 - $480 - 1200 \text{ t/km}^2/\text{year}$
 - Floods 10 times a year
 - The bay flushes 2 –5 times a year

**Burning and land clearing are the major causes
of soil erosion within the La Sa Fua watershed**

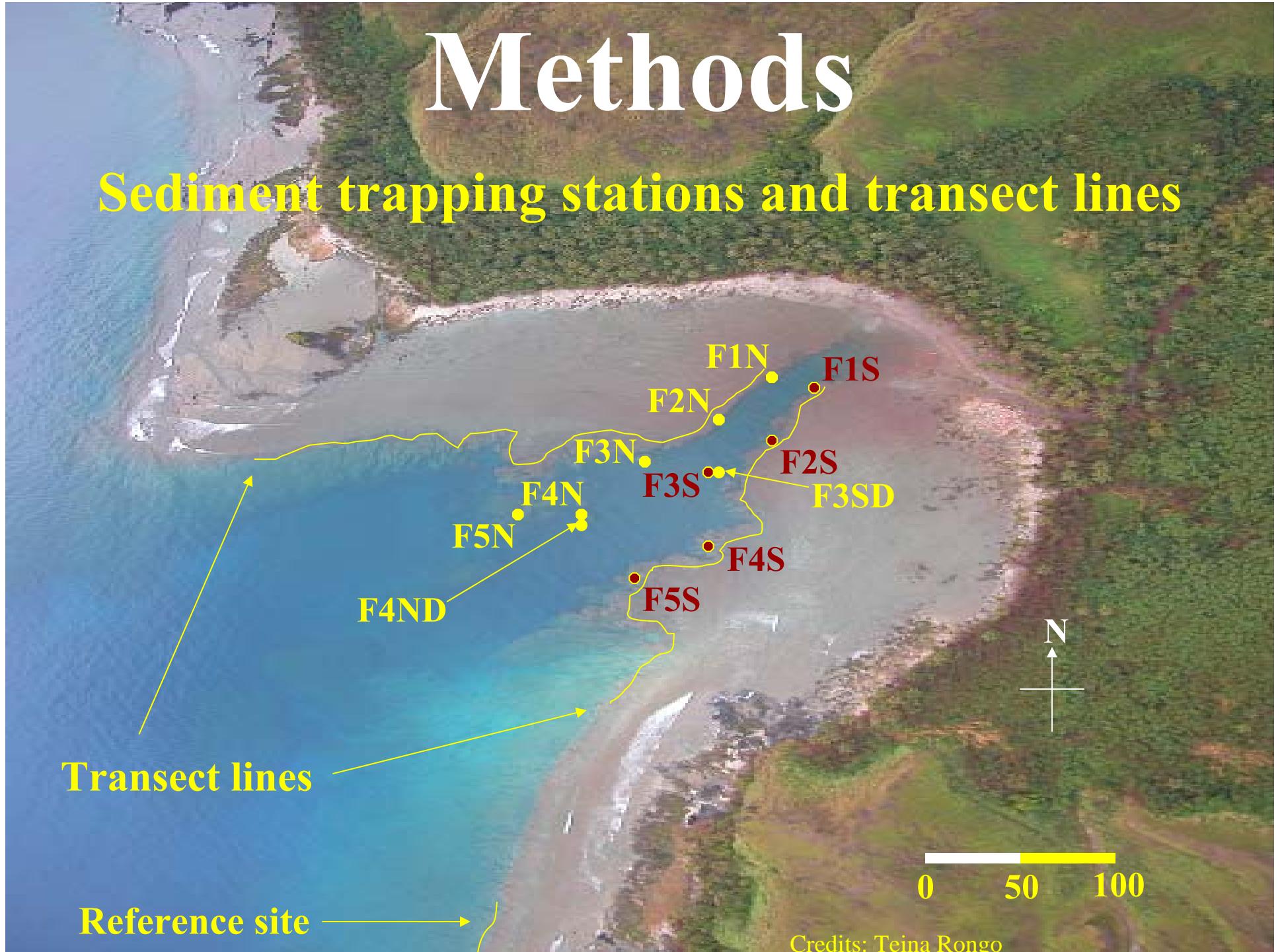


Sediment plume

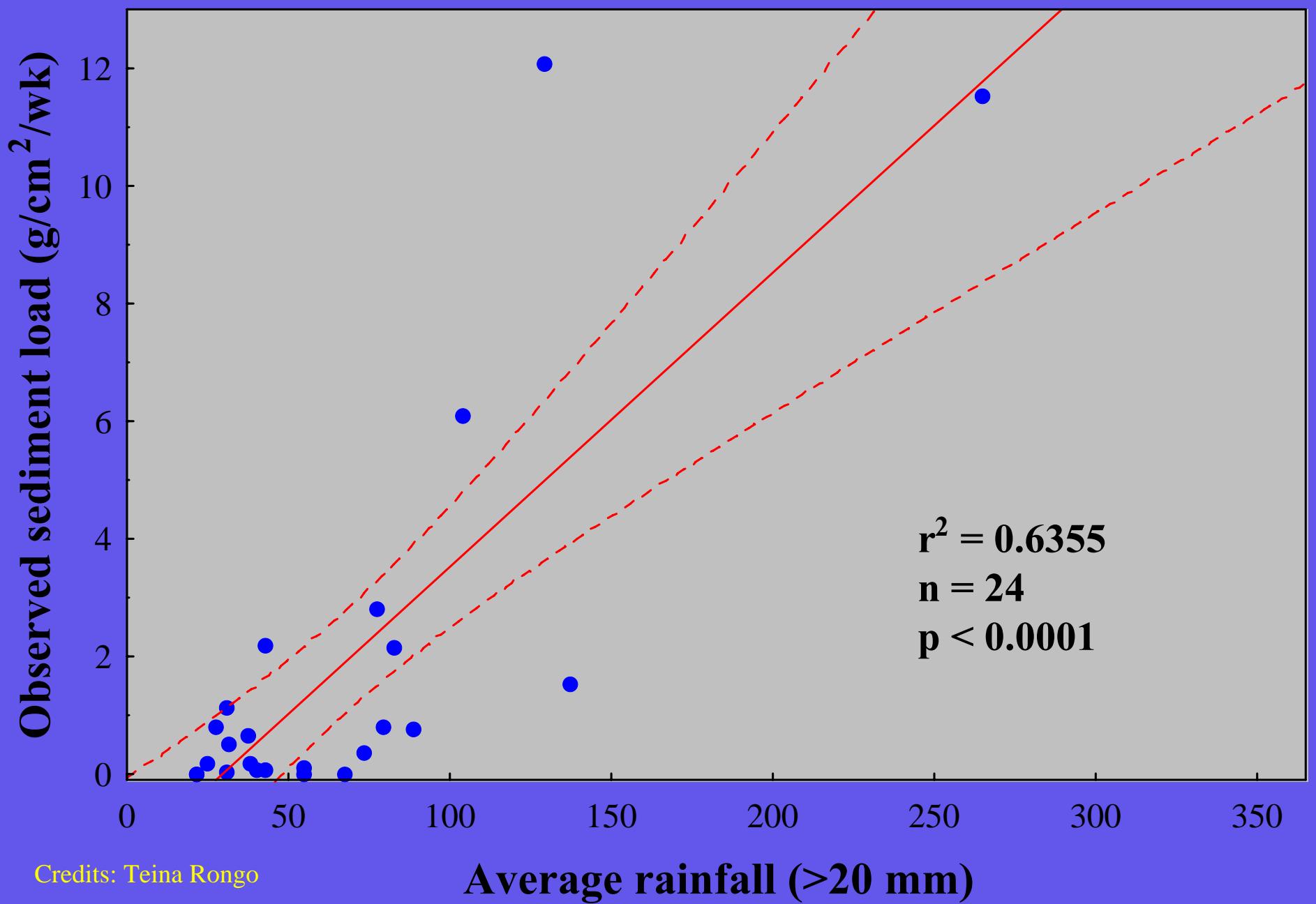


Methods

Sediment trapping stations and transect lines

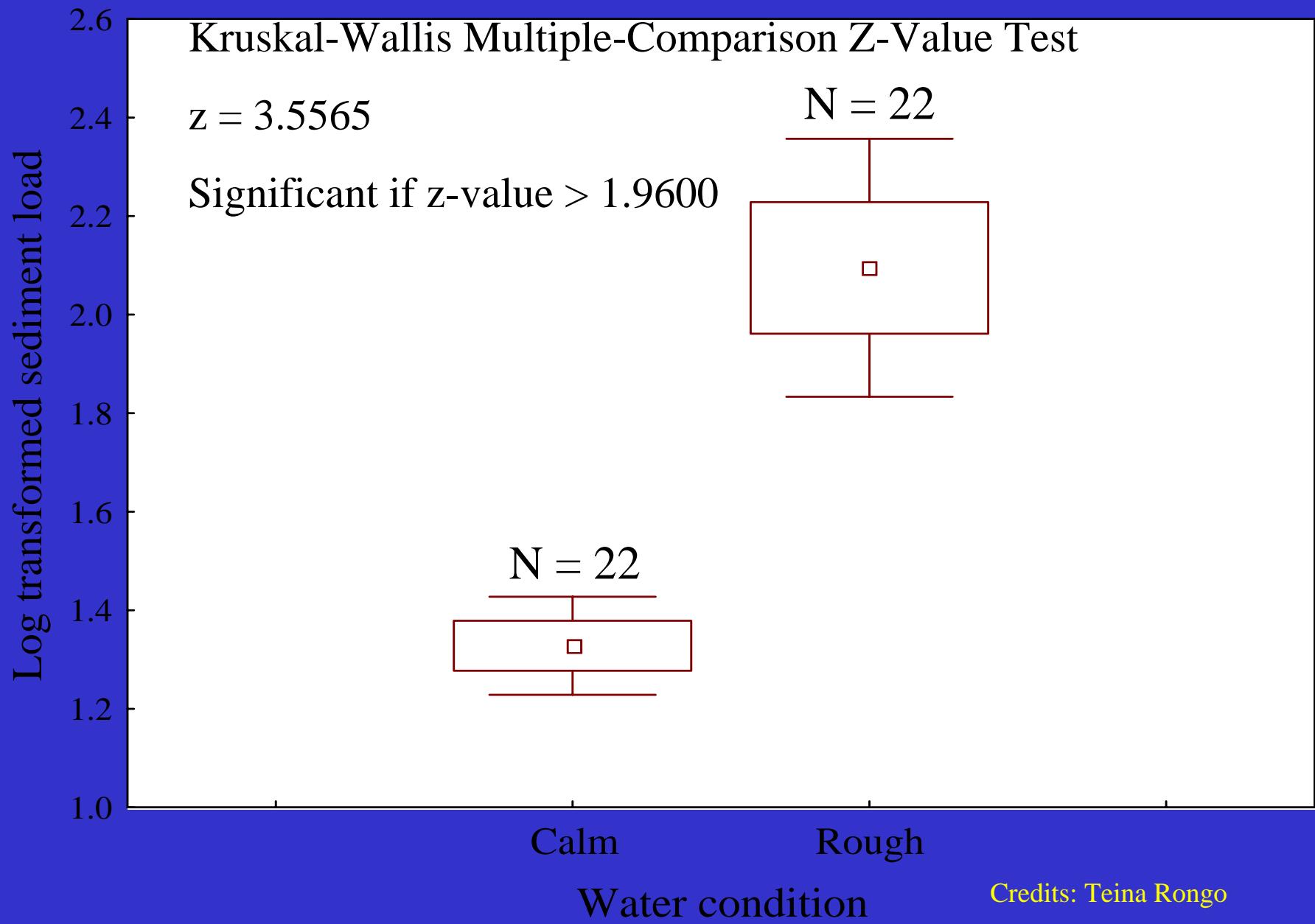


Correlation between sediment rate and rainfall at F1S

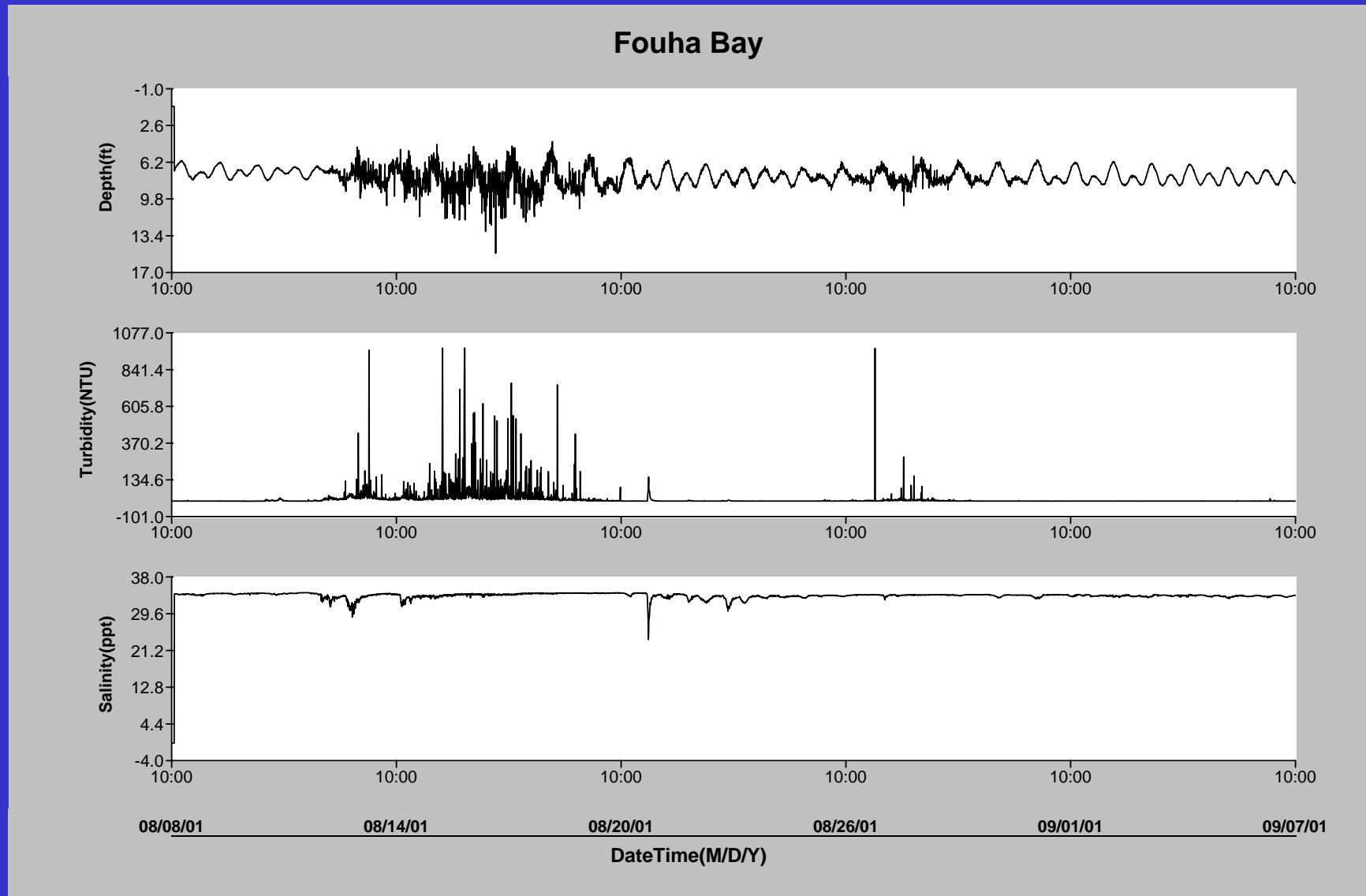


Credits: Teina Rongo

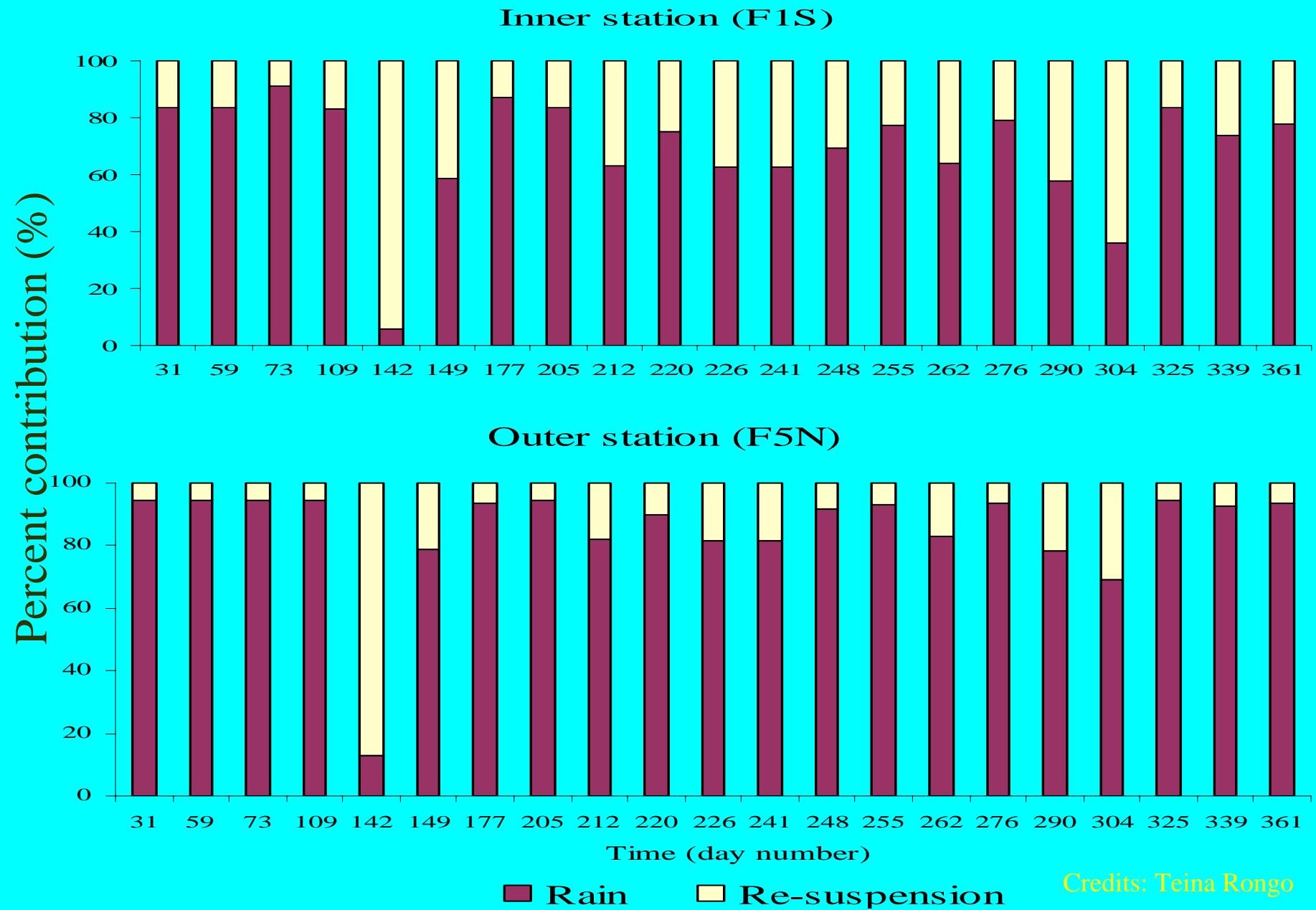
Sediment load between rough and calm periods



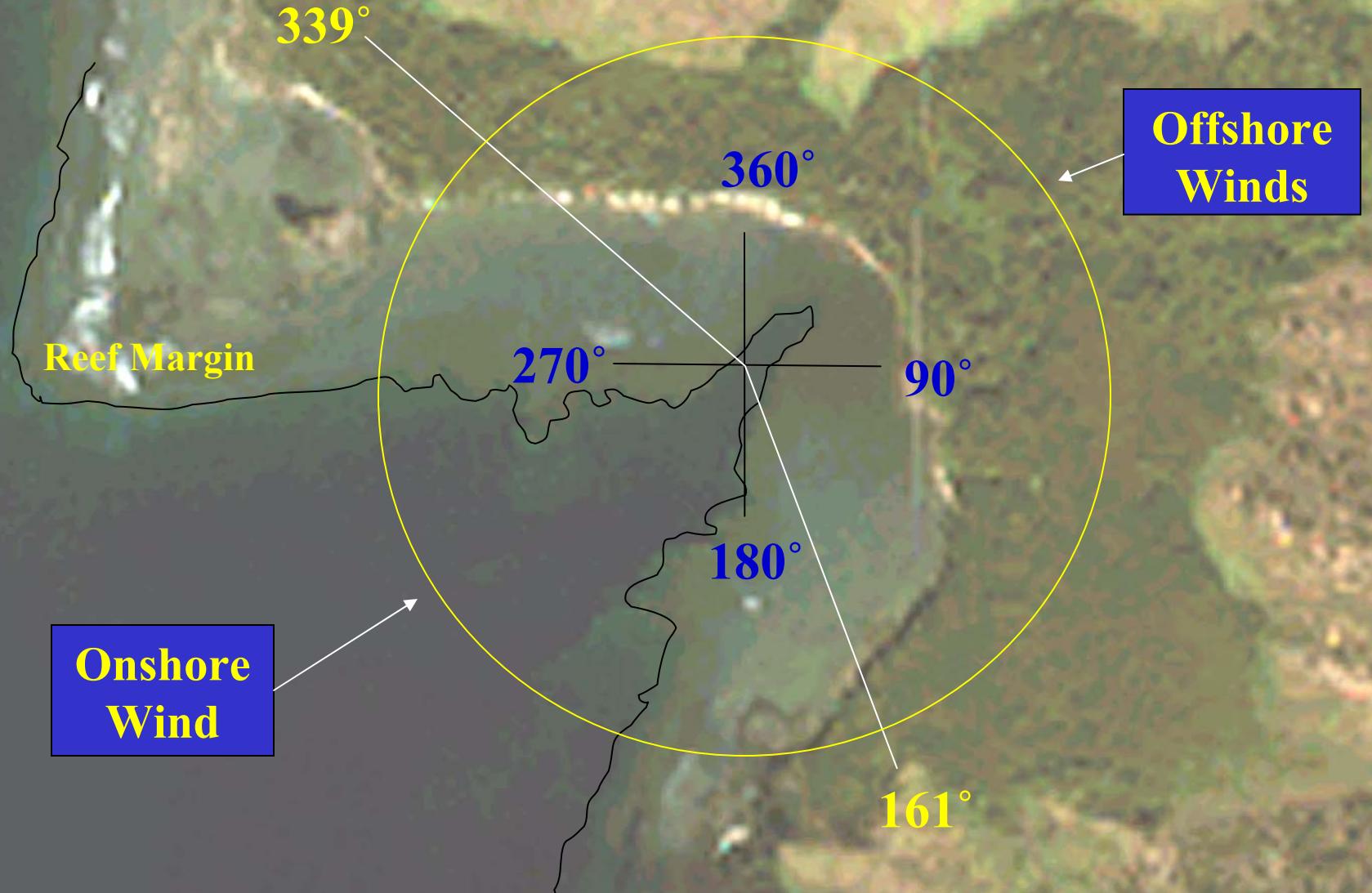
Turbidity/salinity/wave profile – Fouha Bay, Guam



Ratio of runoff sediment to resuspension based on model data



Wind data selection



Ikonos photograph of Guam

Credits: Teina Rongo

Stationary model equations

Stationary model (SM):

$$SM = IF (R_{obs} > R_{lim}, kr_1 (R_{obs}) + kw (W_{obs})), IF (R_{obs} < R_{lim}, kr_2 (R_{obs}) + kw (W_{obs}))$$

Stationary + swell (SM + S):

$$SM+S = IF (SI = 0, SM), IF (SI > 0, k (SM))$$

Stationary + swell + strong wind (SM + S + Ws):

$$SM + S + W_s = IF [W_{obs} > W_{lim}, k (SM + S), IF (W_{obs} < W_{lim}, SM + S)]$$

SM = stationary model

R_{obs} = observed rainfall

R_{lim} = rainfall with some limit

kr_1 = first rain constant

W_{obs} = observed wind

kr_2 = second rain constant

kw = wind constant

S = swell

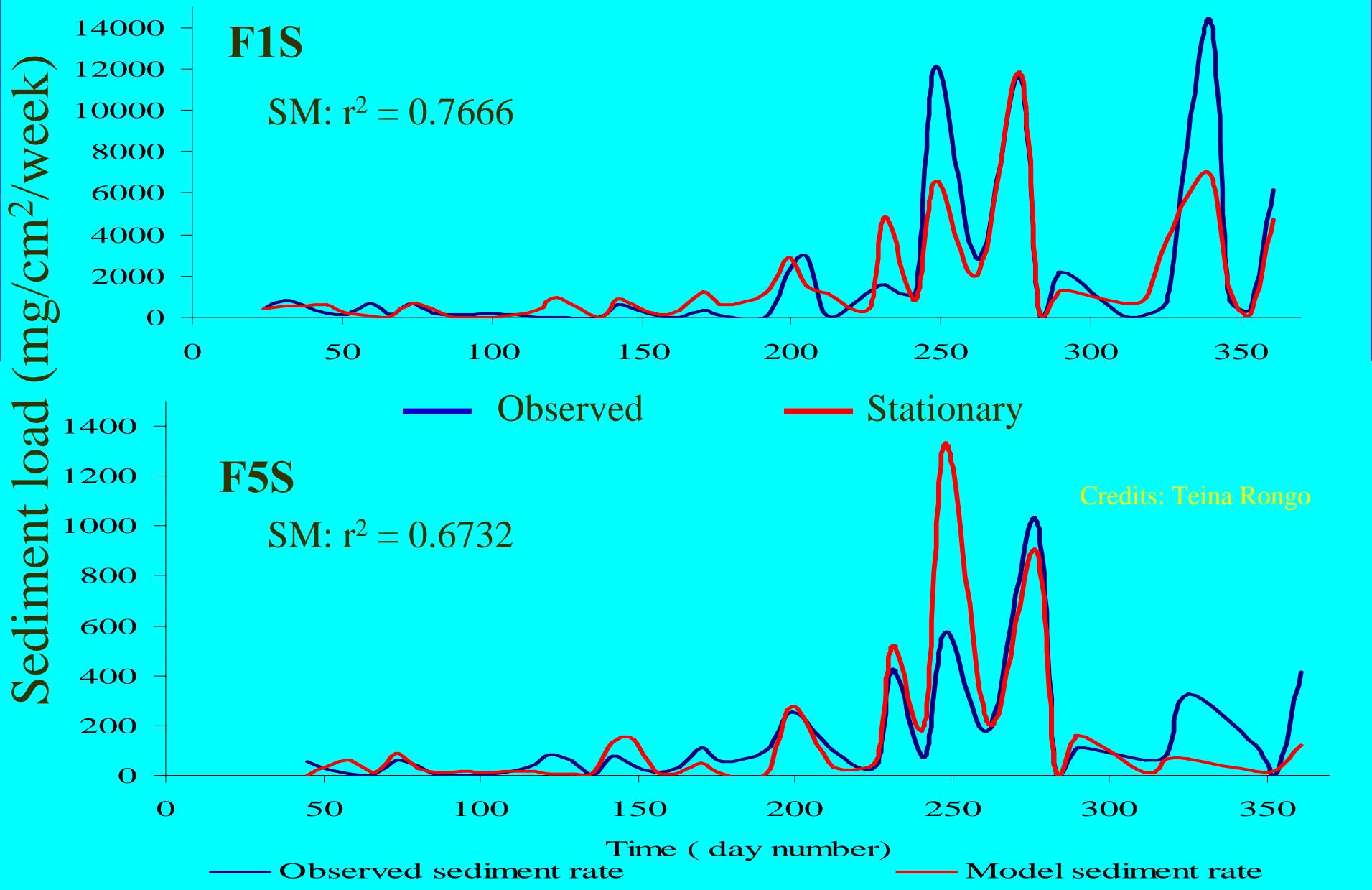
SI = swell index

k = constant

W_s = strong wind

W_{lim} = wind with some limit

Preferred model (stationary)



Categories

1. Large encrusting

Montipora spp.

Galaxea spp.

Cyphastrea spp.

Psammacora spp.

Coscinarea spp.

Pavona varians

2. Small encrusting

Stylocoeniella armata

Porites vaughani

P. solidia

Acanthastrea echinata

3. Massive

Porites lutea

P. Australiensis

P. Lobata

4. Sub-massive

Favia spp.

Favites spp.

Platigyra spp.

Goniastrea spp.

Leptoria phrygia

Monastrea curta

5. Large branching

Millepora spp.

Pavona divaricata

P. venosa

Porites rus

P. annae

6. Small branching

Acropora spp.

Pocillopora spp.

7. *Leptastrea purpurea*

Moving Window Analysis (MWA)

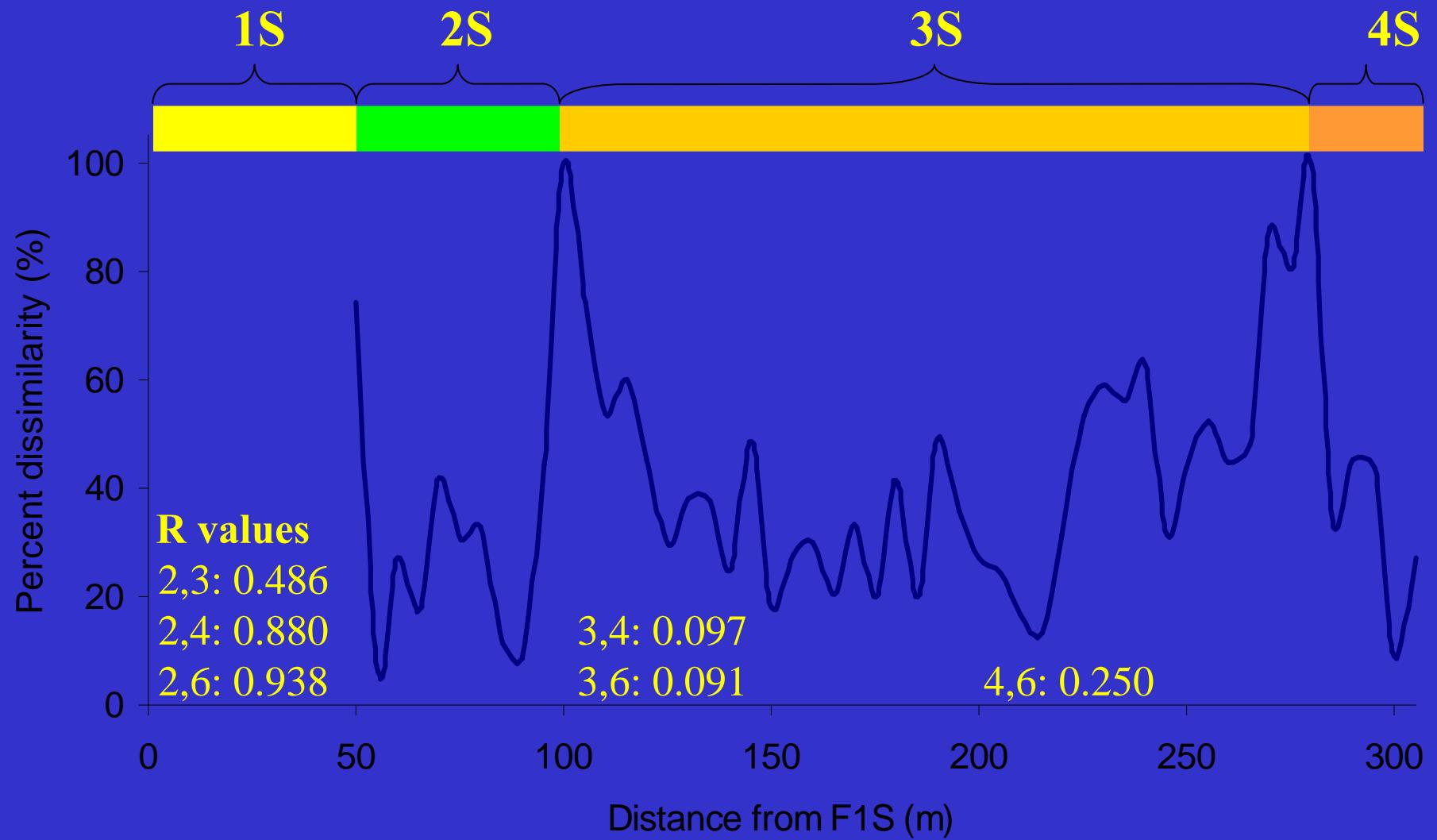
Bray-Curtis dissimilarity distance:

$$D_{jk} = \sum_{i=1}^p \frac{|(y_{ij} - y_{ik})|}{(y_{ij} + y_{ik})}$$

Credits: Teina Rongo

MWA for South

Reference
6



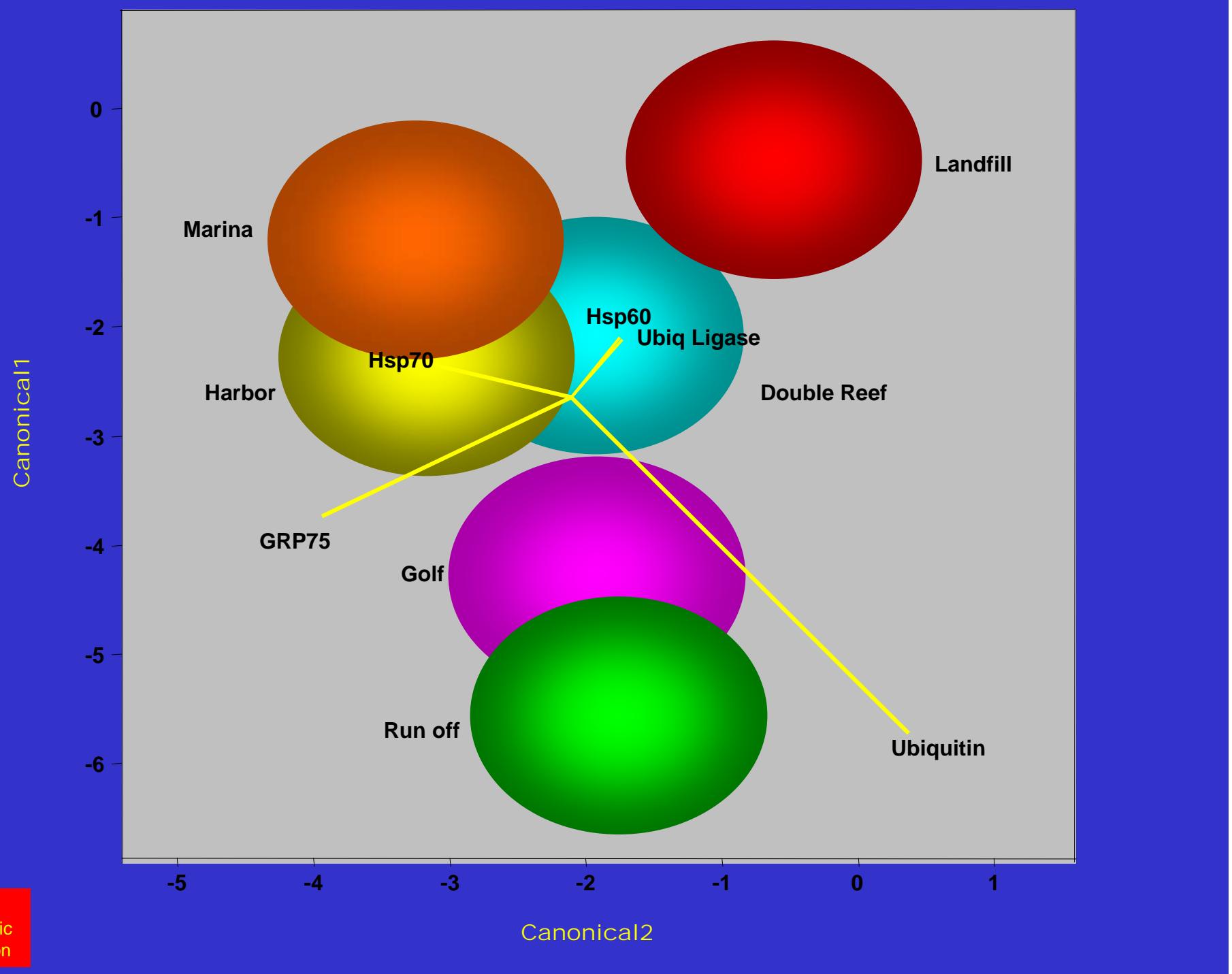
Sediment yield

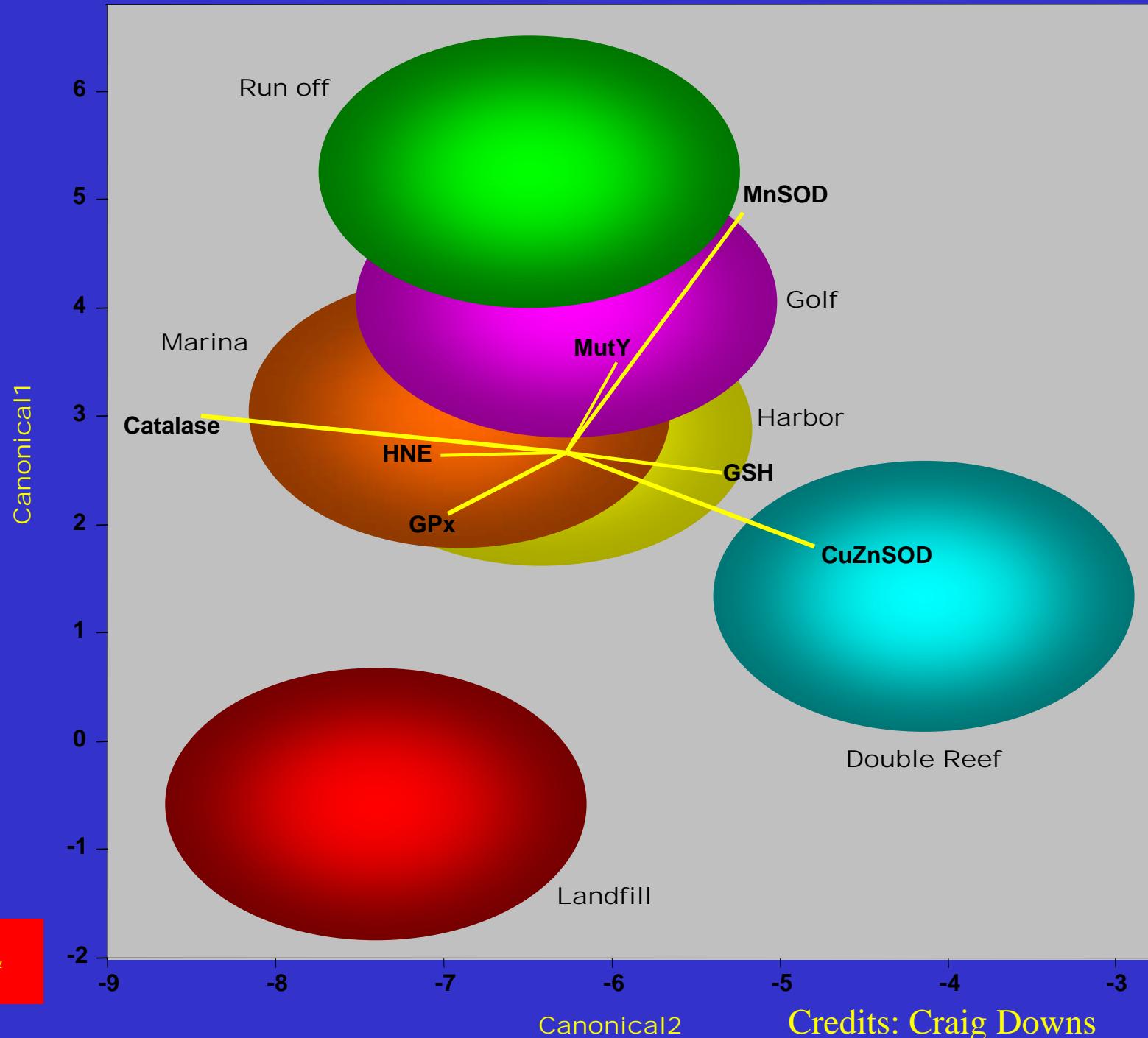
Wolanski, presentation (2002)

River	Watershed Area (10^6 km^2)	Load ($10^6 \text{ tonne year}^{-1}$)	Yield ($\text{tonne km}^{-2} \text{ year}^{-1}$)
Yangtze	1.9	480	252
Amazon	6.1	1200	190
Mississippi	3.3	210	120
Ganges/Brahmaputra	1.48	2180	1670
Mekong	0.79	170	215
Fly	0.076	116	1500
Cimanuk	0.0036	15.7	6350
R & B (1978)	5×10^{-6}	4.71×10^{-6}	1
La Sa Fua (2002)	5×10^{-6}	2.4×10^{-3}	480
THIS STUDY (2003)	5×10^{-6}	5.05×10^{-5}	20

Mortality is a Rather Crude Indicator of Stress







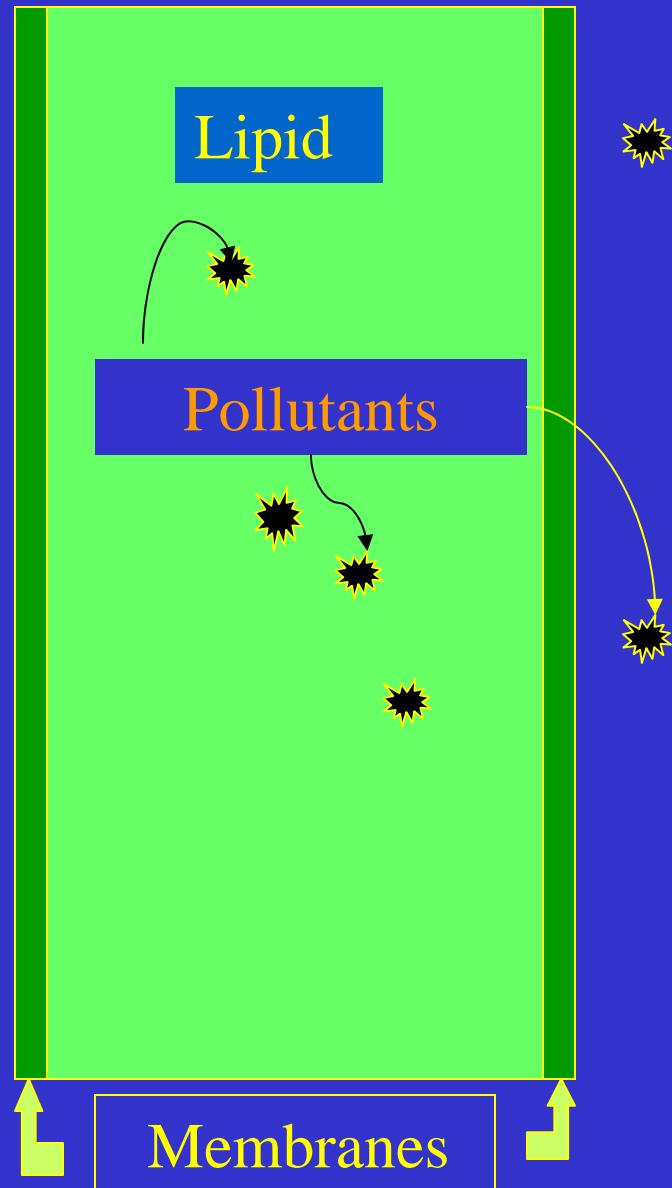
Grounding Incident

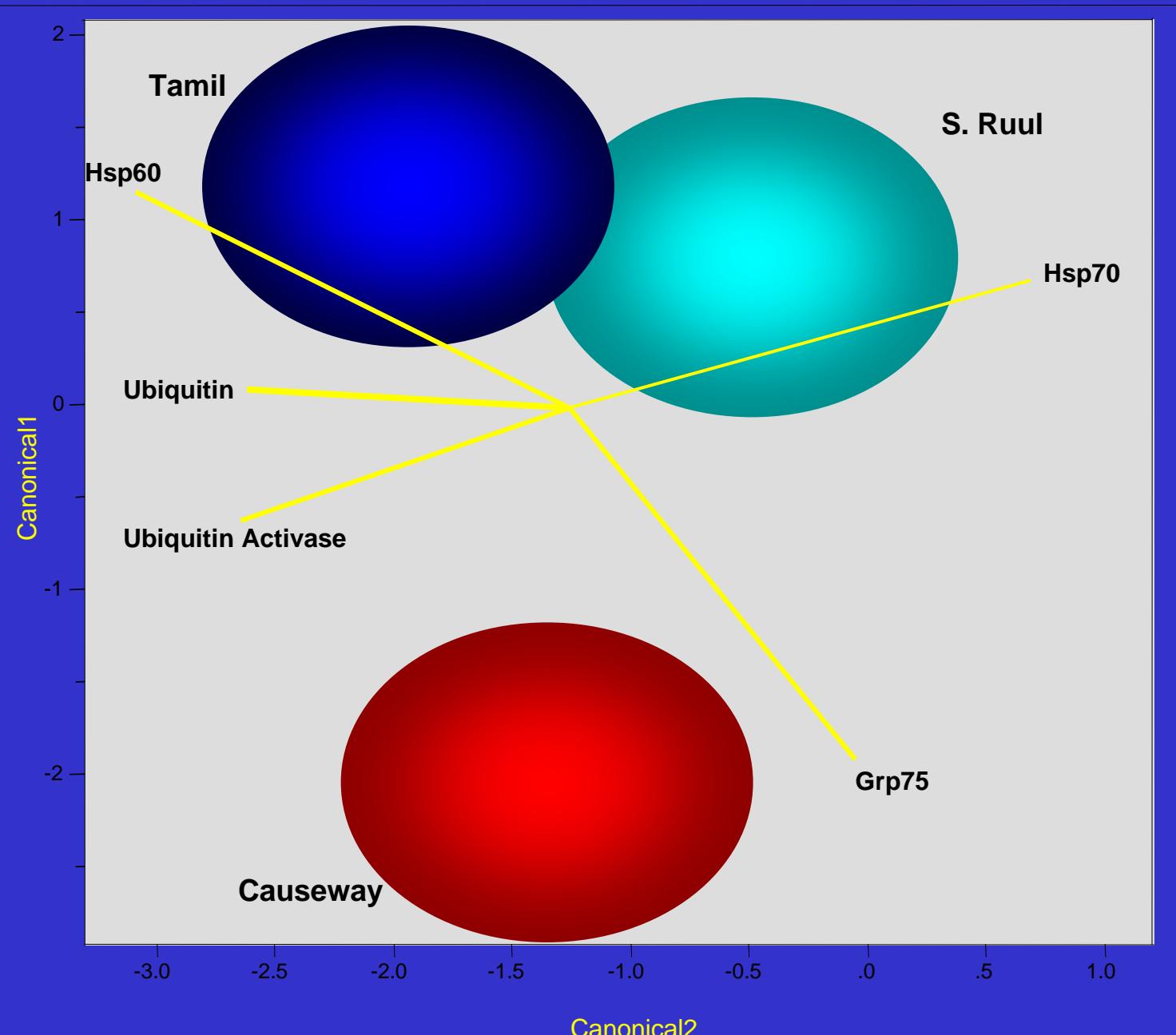


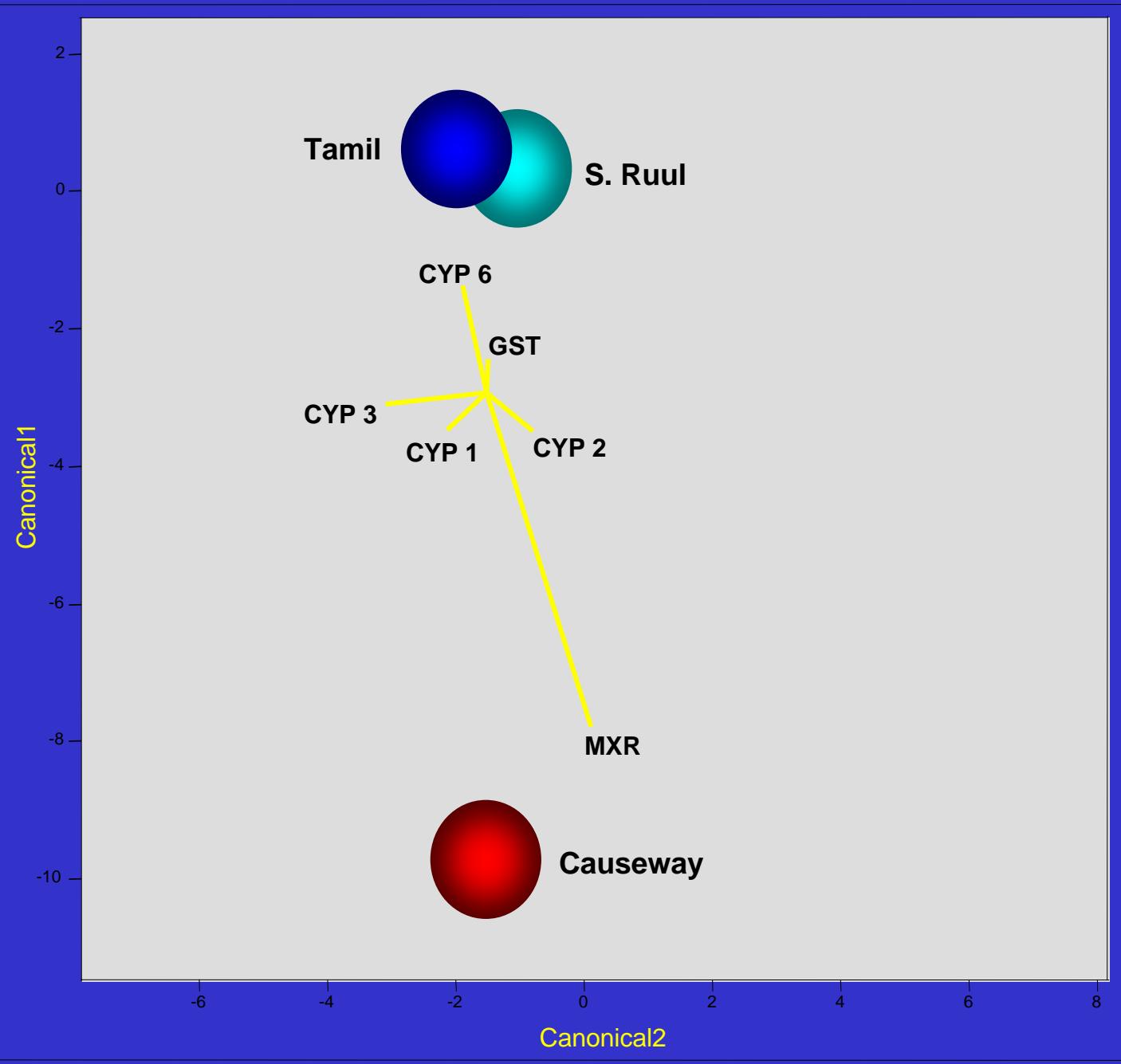
Intermediate Fuel Oil



Semi-permeable Membrane Devices (SPMD's)

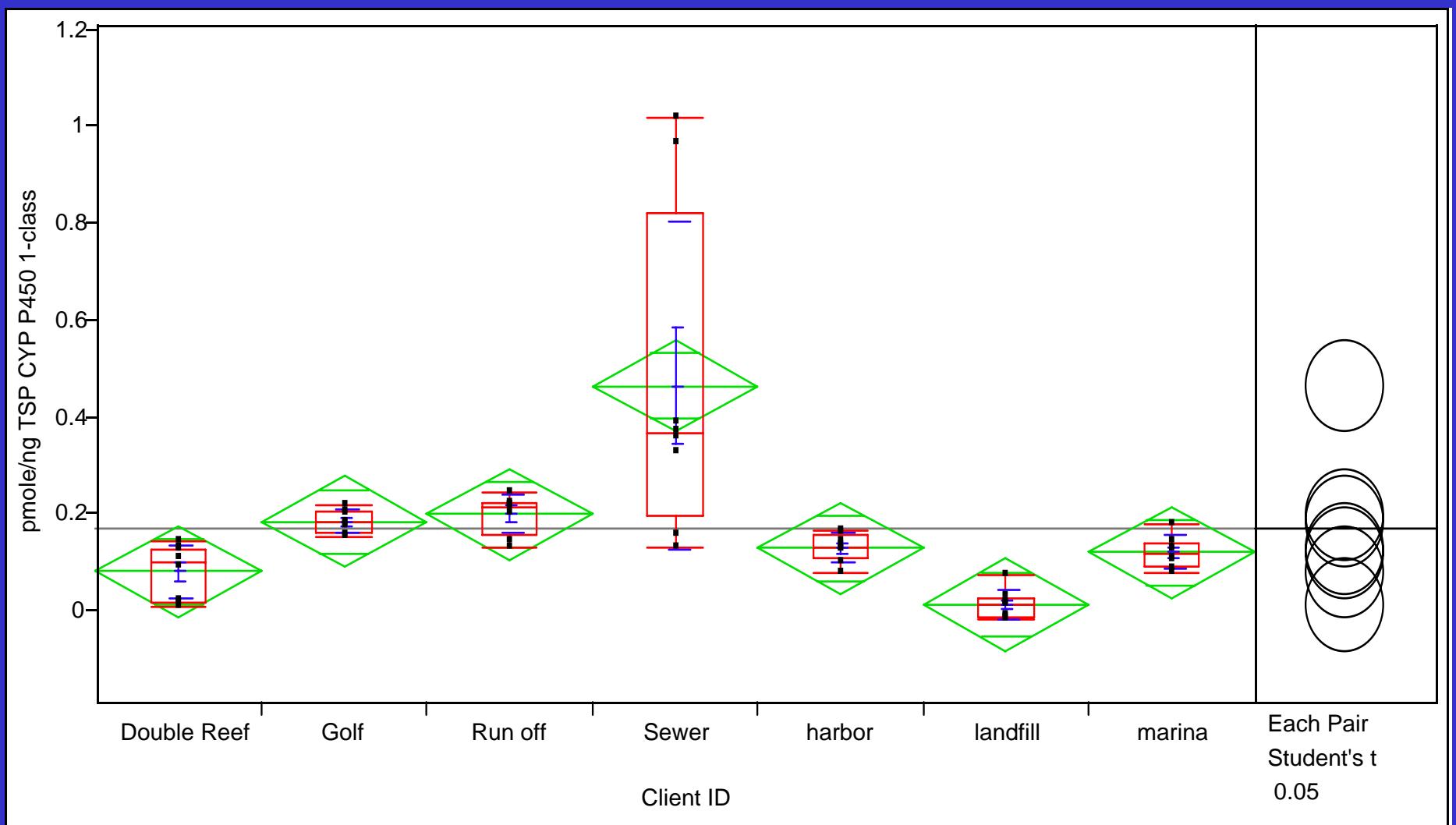




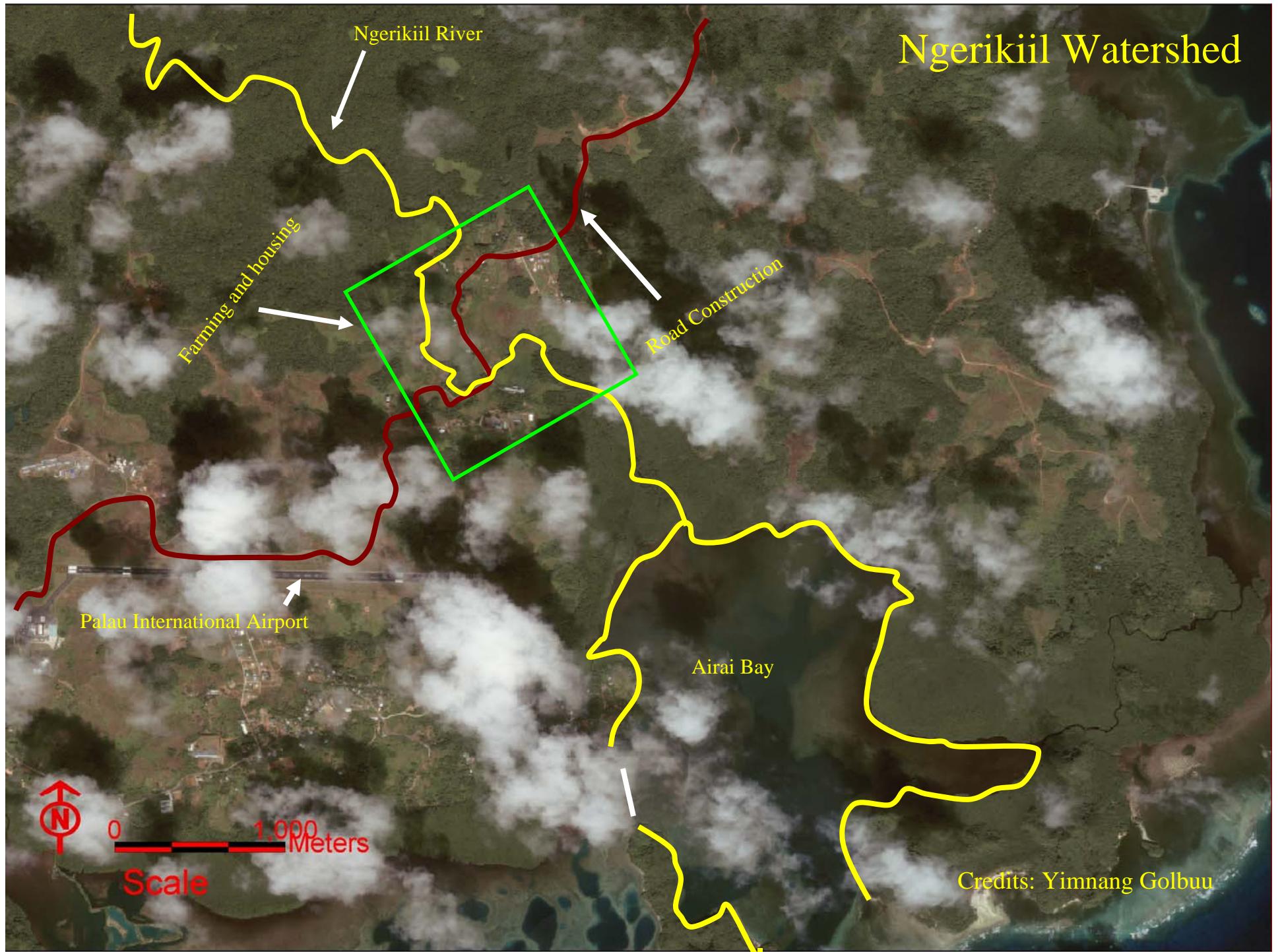


Xenobiotic
Response

Biomarkers of Exposure to Pollutants

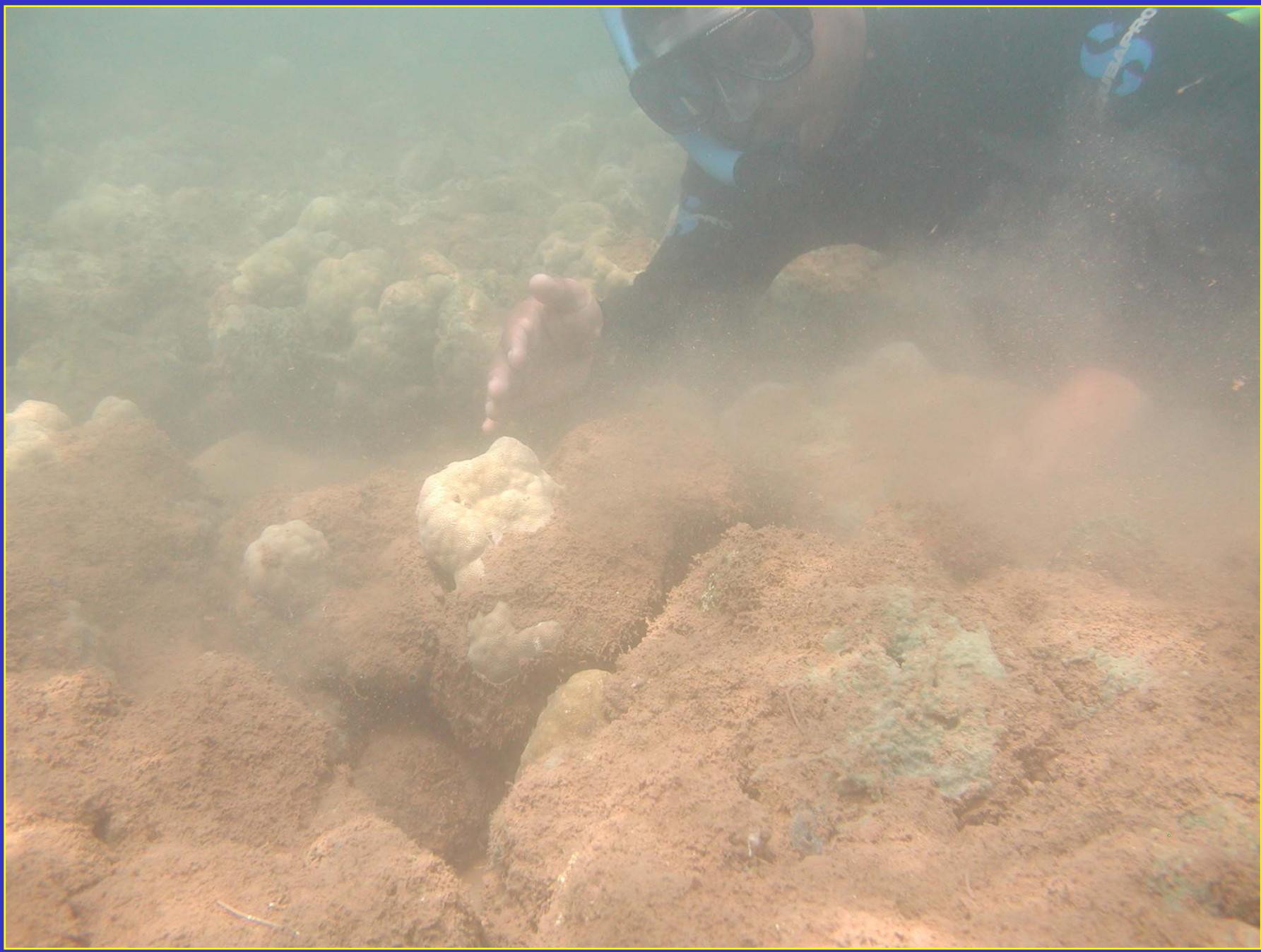


Credits: Dr. Gary Ostrander, JHU; Craig Downs, EnVirtue

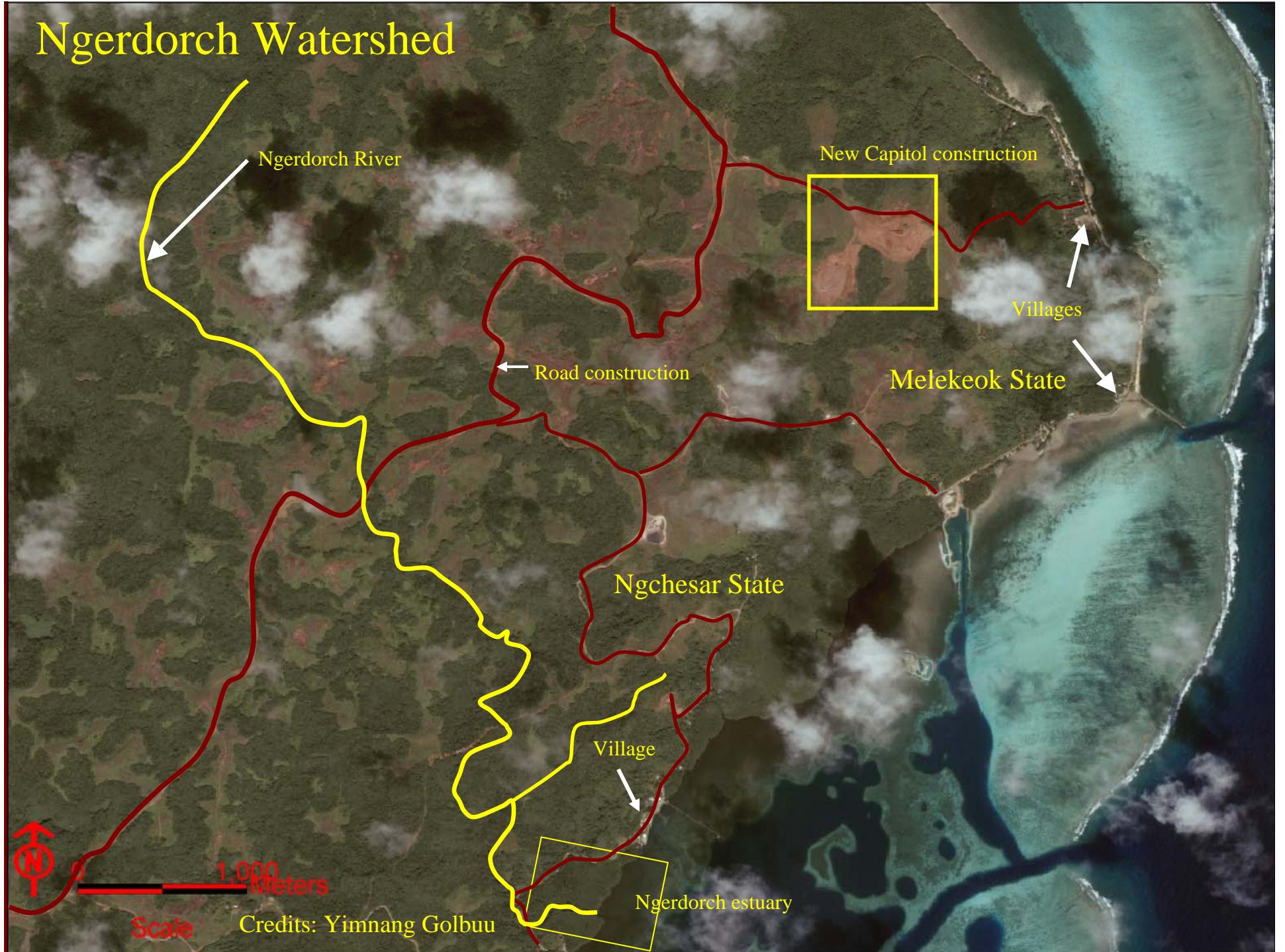




Credits: Yimnang Golbuu



Ngerdorch Watershed

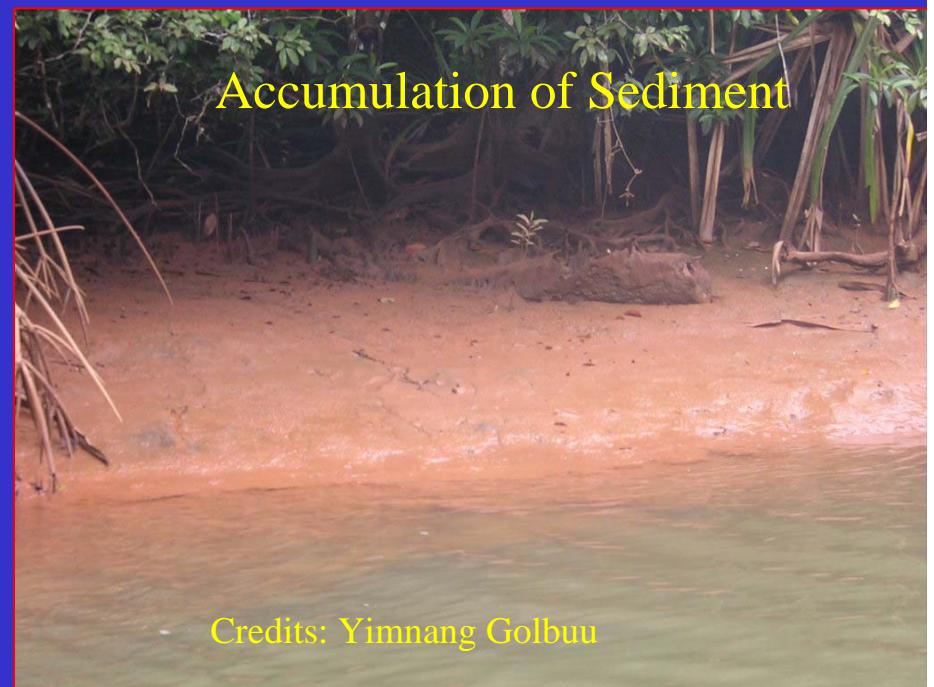


Study Site 2 - Ngerikill Bay – Republic of Palau





Ngerdorch watershed development (within last 5 years)



Credits: Yimnang Golbuu

Sediment Summary

	Ngerikiil Land use Change	Ngerdorch Little Change
Catchment Size (km ²)	19	39
Mean estuarine SSC(mg/L)	500	19
Mangrove area/catchment area	3.8%	3.8%
Trapping in mangroves	15-30%	28-44%
Sediment yield (tons/km ² /year)	150	1.9
	Y.Golbuu et al., 2003 ECSS 57, 1-9	S.Victor et al. In press (WEM)

Credits: Yimnang Golbuu

Pohnpei, FSM



Conservation Society of Pohnpei



Pohnpei community conservation officers



Stakeholder Involvement





ACKNOWLEDGEMENTS

Dr. Sandra Romano, Steven Victor, Dr. Eric Wolanski, Yimnang Golbuu, Sarah Leota, Dr. Scheila McKenna, Victor Bonito, Cynthia and Keana Richmond, Gerry Davis, Noah Idechong, Andy Tafeligeichig, Dr. Chuck Birkeland, Dr. Gary Ostrander, Craig Downs, Dr. Mike Hadfield, Teina Rongo, Aja Reyes, Dr. Vekila Vuki

National Institutes of Health –SCORE Program

NOAA CSCOR/COP/CRES

U.S. Environmental Protection Agency - STAR

National Science Foundation

Dept. of the Interior, OIA